BOSTON UNIVERSITY

GRADUATE SCHOOL

THESIS

AN INVESTIGATION IN REGARD TO THE FUNCTIONING OF SECONDARY MATHEMATICS.

SUBMITTED BY

MARGARET MARY HINCHEY

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AN INVESTIGATION IN REGARD TO THE FUNCTIONING OF SECONDARY MATHEMATICS.

OUTLINE

Margaret M. Hinchey.

OUTLINE

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AN INVESTIGATION IN REGARD TO THE FUNCTIONING OF SECONDARY MATHEMATICS.

There is at present a great interest among educators and students of education in the curriculum and its content. Within the past thirty years, many new studies, such as manual training, industrial and household arts, agriculture, civics and vocational training, supported by able advocates, have found their way into the high school course. With the increased number of topics, there has naturally been a decrease in the amount of time which could be devoted to each subject, and it is quite common today, in an up-to-date school, to have as many as eighteen or twenty different studies, with pupils reciting in seven or eight different subjects in one day. The tendency has been to condense the knowledge, with the result that a pupil very often receives but a sketchy, superficial training.

As a result, the general recognition is now prevalent that the entire curriculum should be reconstructed to meet present needs and conditions. The new principle, upon which

subject matter and content must be weighed and revaluated, is this: "No item shall be retained for any specific group of pupils, unless, in relation to other items and to the time involved, its(probable) value can be shown."[1.]

Perhaps as much as any other so-called traditional subject, mathematics, including algebra and geometry, has been attacked by the extremists, who see no reason whatsoever for its place in a present-day program. We, who are students of mathematics, hold no such radical views, but, in absolute fairness and justice, we cannot but recognize and realize to the full extent, the inefficiency of the traditional mathematics course.

We are told that the old curriculum was undemocratic. The content of mathematics, like that of practically all the traditional subjects, was determined largely by the College Entrance Board. Now it certainly does not seem democratic that the public schools of our country, supported by the people of the community and maintained for the education of their children, should be dominated as to their curricula by a small group of men, teachers in private colleges. And yet, in a bulletin published in 1912, by a committee on the "Teaching of Mathematics",[2.] the statement was very plainly made, that, "While the course of study in mathematics is nominally fixed by the governing body of the school, after

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1. See Bibliography, Page 1, no. I.

2. " " " 1, no. II.

conference with its principal, and, to some extent, with teachers of mathematics, it is in reality almost entirely determined by the entrance requirements of the college." The demand made by the colleges was largely for selective purposes, and was limited almost entirely to abstract theory and manipulative gymnastics.(3)

Again, our schools are accused of being undemocratic, in that they satisfy the needs of but a small group of children. Only between five and ten percent of those who attended high school ever reached college.(4) Still, to the entire hundred percent, we offered, not equal, but identical courses, which were planned preeminently as a preparation for college. For children of the book-minded type, this was very well, but the majority of children have not these distinctively intellectual tastes--- they are motor-minded and for them, other courses besides Latin and algebra would have been more appropriate and beneficial. Very frequently too, the compulsion of certain subjects for those who had no taste or desire along such lines brought about a disgust and hatred for school, for education, for learning in general, which can never be offset by any possible benefits they might have derived fron their training. Schools,which are publicly supported , should offer equal advantages and opportunities, in so far as this is possible, to all children who attend.

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3. See Bibliography, page 1, no. III.

4. " " " 1, IV.

But in our public schools, we offered a single mathematics course, planned by the authorities of the college, to all students, regardless of their tastes or abilities. This meant that only a small minority could receive the most benefit from it. Though we realize that the pupils derived some educational value from all the subjects in the curriculum, we question whether they received the maximum, in proportion to the time amd effort spent, when we consider their aptitudes and outlook for the future. Viewed from the light of our educational beliefs and policies now , they did not, and hence the mathematics course was undemocratic for that very reason.

In the high school of a generation ago, certain traditional subjects, including mathematics were stressed and exalted to a throne-- to an aristocracy which was so narrow that it could not meet the real needs of a nation like ours.(4) Those few who were given the opportunity of studying the mathematics of the carpenter or of some other trade, in place of algebrs and geometry, were rather looked down upon by their companions. It was considered a very inferior type of work, and the pupil who studied it, of a much lower intellectual grade than the rest. Even today, this idea has persisted to a considerable extent, and, recently, a type case was mentioned in a lecture, where pupils attending the classical high school in a certain city practically ignored and

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4. See Bibliography, page 1, no. IV.

shunned those who were students in the technical or trade school. This snobbishness, which the lauded traditional subjects have created, cannot and should not be tolerated in our public schools. Thus far we have seen that our traditional mathematics curriculum was, in a great measure, influenced by the College Entrance Board requirements, that in consequence of this limitation of its scope, it failed to meet the needs of all pupils, and finally, that it created and fostered a very real intellectual snobbishness, traces of which may be evidenced at the present day.

With the progress of educational science in the last ten years, certain theories upon which courses and syllabi were based, have come to be questioned, and , in some cases,rejected entirely. Now a course of study,based on doubtful or worn out psychological principles, is both unsound and inadequate, and most inefficient in the light of modern thought. Practically all subjects which have found their way into the curriculum possessed at one time definite instrumental value. When, because of changing social conditions or a changing population, the need passed, the subjects of the traditional curriculum still remained, but they were then justified on the grounds of "mental discipline". Recently, this theory has been questioned, so today, while the actual possibility of transfer is not denied, it is felt that "no mathematics topic should be considered in the hope that it may somehow aid in the develop-

ment of general abilities." (5)

This whole doctrine of mental discipline was based upon the theory of "faculty psychology"---that is, the mind was composed of so many faculties or powers, such as perception, memory, judgment, and in accord with this notion of the mind, the formal disciplinists believed that a faculty once trained was good for any service.(6) Thus it was not the mind, but only the faculties, which were trained. In scientific circles today, faculty psychology has been supplanted by the theory of functional psychology, which affirms the unity of the mind, as it adjusts itself variously to different situations. The isolation of subjects, since each was intended to result in the development of a distinct function, was also a feature of the traditional curriculum. The practical effect has been to emphasize the separateness of individual studies, and to cut off the natural connections and associations among them.(7) Organization and correlation, which are the distinct and dominant marks of our present mathematics course, are the final negation of this old concept.

That training in one line of mental activity would improve abilities along other lines of mental activity, was believed even without the specifications of certain definite objectives and purposes. Often a teacher in response to a question as to why mathematics was studied, would reply that it developed the power of reasoning, generalization, the ability to think clearly in

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5. See Bibliography, Page 1, no. V.
6. " " " 1. no. VI.
7. " " " 1, no. VII.

terms of ideas and concepts, or some other vague and indefinite objective. A psychological experiment described by Pyle would seem to prove "that objects, which appeared in the field of vision, but were not especially attended to, were no more easily learned later, than if they had never been seen. In ideational learning, objects must be in the focus of attention." (8) This, it seems, has been the trouble with the traditional mathematics,---namely, that without mentioning or particularly directing the attention of the pupils to the particular phases of mathematics which it was hoped would develop certain qualities in their minds, it was assumed that since the pupils were exposed to these desirable traits, they would unconsciously imbibe them.

It might be well to remember here that there is a distinction between the relative and absolute value of mathematics,- that, "though mathematics may have been of value in the line of developing reasoning power, accuracy, et cetera for some, still it does not follow that it is the only subject which will do this. To justify its existence, it must be shown that for those stydying it it is more valuable than all other possible aims." (9)

Though the question of transfer of training is a much disputed one, and the scientific evidence on the matter rather meager, the conclusion from investigations and the judge-

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8. See Bibliography, page 1, no. VIII.

9. " " " 1, no. IX.

ment of psychologists is that transfer does exist, though not always, and that, in any case, the amount of transfer depends very largely upon methods of teaching.(10) Charles H.Judd of the University of Chicago has said,"The real problem of transfer is a problem of so organizing training that it will carry over in the minds of the students into other fields. Mathematics as a subject cannot be sure to transfer. All depends on the way in which the subject is handled." No longer then can the traditional mathematics program be justified on the basis of mental discipline----"wholesale transfer of training as the sole principle of selection of subject matter is permanently discarded."(11)

It was this theory of mental discipline which was the basis for the statement in a Bulletin,published in 1912 in regard to mathematics for the pupil who is not going to college:"It is held that the essential benefits of the study of mathematics can be attained as readily and as fully in the study of the subject matter, required for admission to college, as in any other selection of topics, and so courses in mathematics offered to all pupils conform to current collegiate entrance requirements." (2)

As this statement is typical of the attitude which

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10. See Bibliography, page 1, no.X.
11. " " " 2, no.XI.
2. " " " 1,no.II.

formerly prevailed, so the more modern view is quite well expressed by Calvin O. Davis,(12) who says, "If mental discipline be the desideratum for admission to college, may not subject matter that has a rich content for practical life, also be made to furnish as desirable and as satisfactory mental discipline as do the traditional subjects, the social utilities of which have been largely lost."

Another practice which today is held in disregard but which also contributed to the inefficiency of the traditional program was the strict logical order, in which the subject was taught. Topics were presented to the pupils as they were scientifically arranged, and so in the study of algebra, for example, it would be necessary for the pupil to master the four fundamental processes and then the more complicated manipulations, before he was allowed to even attempt a problem. The traditional order and arrangement of dubjects from the viewpoint of the complete systematic knowledge of the adult, is not considered to be psychologically sound today.(7) The modern teacher assumes that the child is a very crude developing organism, and realizes that at least fifteen years of normal growth are required to reach the adult level. Educational science now holds that topics for study be presented from the child's viewpoint---captivating his interest first, and through this interest developing the rest of the subject. Motivation is a real vital element in successful teaching

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12. See Bibliography, Page 2, No. XII.

7. " " " 1, No. VII.

today. Because of this fault in the traditional program, the mathematics was inefficient, and the need for the reorganization of the order of content and of methods was strongly felt.

The fact that little cognizance was taken of the individual differences in the pupils, also tended to make the mathematics course, which was planned for the "average pupil", inefficient. Great emphasis was placed upon standards, and all the children who did not live up to the standard were considered inattentive or indifferent.(13) A few might be stupid, but it was the teacher's delight to have the entire class as uniform as possible. Not alone the teacher,but topics and text books as well, have all tended to increase this uniformity. The result was that a mathematics course was offered in identically the same form to all pupils, regardless of their intellectual abilities, their tastes or desires. We recognize now that differentiation in the mathematics of various types of pupils is necessary. Up to that leval where the need is common to all, the schools should offer the same mathematics to all. Beyond that point, however, mathematics needs to be adapted to the probable future needs of the individual.(14)

If the purpose of education is adjustment, and we know that individual children differ in environment, competency,

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13. See Bibliography, page 2, no.XVIII.

14. " " " 2, no.XIV.

and inclinations, does it not follow that their training along mathematics lines should also be different? Both social and industrial well-being argue against any attempt to mould all citizens in one form.(12) The traditional mathematics offered the same course for the boy who was preparing for continued schooling, or for the boy who planned to enter immediately into the active and practical affairs of life. The mathematics curriculum of the present must be made broad enough in scope and flexibility to meet, in an adequate fashion, the needs, not of the average boy, but of the individual pupil.

On account of the great uniformity which prevailed, teachers were apt to become mechanical, and the work soon became monotonous. Such conditions resulted, naturally, in a large percentage of retarded pupils. Perhaps because of the very definiteness of the subject and the ease with which it can be standardized, there is greater chance for failure here. According to Stout,"No other subject in the curriculum has recorded against it the percentage of failures recorded against mathematics."(11)

The following table was taken in substance from the report of the N.Y.State Education Department, showing the percentage of pupils failing in mathematics subjects for January and

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12. See Bibliography, page 2, no. XII.

11. " " " 2, no. XI.

June, 1913. Sixty percent was the passing mark.

Subject.	Percent Failing.
Elementary algebra.	28.5
Intermediate algebra.	36.5
Advanced algebra.	26.6
Plane geometry.	40.2

While the element of uniformity, resulting in mechanism, disinterest and retardation, was not the only objectionable feature, and was not solely responsible for these failures, still, to a great extent, it may be blamed for the general inefficiency of the schools, as well as for many of the social misfits of life.

In his book, "The School Survey", (18) Sears tells us that the two great factors in planning a curriculum are the child and the demands of society. When a school program fails to recognize these factors, and to adjust itself to their ever-changing demands, it at once becomes static, and thereby inefficient. Now despite the unprecedented development, which our country has witnessed in the past thirty years, --- in science, medicine, engineering, architecture, transportaion and methods of communication--- until quite recently, our educational machinery alone has remained old-fashioned, poorly constructed and poorly organized. As compared with the progress of other things, education has been inexcusably slow. In a book on certain social phases of education, (19) Dutton has said

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18. See Bibliography, page 2, no. XVIII.

19. " " " 2, no. XIX.

that though he is not"one to disparge or minimize the importance of the work performed by American schools in the past", he feels that our nation has become great and influential, not by reason of public education or of college education, but in spite of it".

Let us first consider the change which has taken place in the high school pupil. Originally, the secondary schools were attended by the children of the richer and more cultured classes in the community. Today the high school is free and open to all who have the ability to profit from its courses. According to the Bulletin of the U.S.Bureau of Education published in 1912, nearly one-fourth of the children who enter the elementary school, eventually pass into the high school. The growing prosperity of the country and the rising standards of living and culture, Sneddin tells us, account for the increase.(20) For the sake of argument, let us suppose the mathematics course offered a generation ago was satisfactory and adjusted to the needs of those pupils. Surely a program satisfactory then could not be expected to meet in an efficient manner the many needs of the cosmopolitan group, who have been enrolling in our secondary schools of late. The continuance of the traditional mathematics course for all pupils would imply this however.

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20. See Bibliography,page 2, no. XX.

It is fairly reasonable to conclude that with this greater number attending the high schools, the average of the natural intellectual endowment of the students is less than formerly.(21) As a result of this, we would expect that corresponding changes would have to be made in the secondary schools. In fact, Morrison says, "that with a change in clientele, the whole purpose and social function of the school should necessarily change, requiring thereby a change in the curriculum. Since school authorities and teachers no longer have to deal with a selected high grade home background, but with a heterogeneous mass from every sort of social stratum, a change in methods will also be necessary."(17)

Compulsory school attendance laws,now operating in practically every state in the Union, have likewisw been a factor in increasing the school population. These statues also bring into the school many pupils who have little taste or desire for the traditional subjects. So the wuestion arises again in regard to the object of the schools. Is their purpose to teach pure mathematics, or is it to teach pupils what will be most beneficial and helpful to them to lead a successful life? I think this answered by Cheesman A. Herrick in his paper,"What High School Studies Are of Most Worth".Though what he says applies directly to subjects, the same principle could also apply to the content of a subject. He gives this

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21. See Bibliography, page 2, no. XXI.

17. " " " 2, no. XVII.

as the guiding principle for a new curriculum: "Those high school studies are of most worth which are worth most to the individual, which will best fit him to meet the many-sided demands of the life which he is to live." (15)

With the advancement of civilization , life has become more complex, and so one needs more and better equipment to cope with the problems of today. The world of finance, the ever broadening business fields, and the economic aspect of so many civic and social problems ----all require a different training than was needed when the country was in a smaller and therefore simpler state.

But despite the fact that social and economic conditions have changed enormously, the course in mathematics remained almost at a standstill until within a few years. Though there was a general tendency to accept the tenet that subject matter in mathematics should assist in the interpretation of life's activities and pursuits, "scarcely any definitely outlined material in harmony with this tenet was to be found in the schools."(16) Secondary mathematics, both as regards content and methodology , has been inexcusably slow in adjusting itself to the current demands.

Another reason which forced us to the conclusion that the traditional mathematics course was inefficient was the general dissatisfaction on the part of the colleges.(17)

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15. See Bibliography, page 2, no. XV.

16. " " " 2, no. XVI.

17. " " " 2, no. XVII.

the business men, and the pupil himself, with the results obtained from it. There was constants complaint from the colleges in regard to the low grade of mathematical scholarshop found among the pupils. Business men too were dissatisfies with the inaccuracy and inefficiency displayed by High School graduates in handling simple arithmetical manipulations, such as were required in ordinary transactions. But the final condemnation of the mathematics course comes from the pupils themselves. There is , according to Meriam, (13) a close correlation between the number of children withdrawing from school before completion and the value of the school work to the child. Various studies have been made in regard to the causes of withdrawal, and it has been found that only about thirty percent can be attributed to absolute economic necessity. Some of the reasons assigned for leaving are desire for activity, indifference, failure in work, and dislike of school or studies. These all seem to point to a lack in the curriculum-- its inefficiency measured by this exodus of pupils from the school into vocational activities. Nor can this be lightly passed over as involving only a few pupils. The results of an investigation made by Ayres show that the percentage of pupils retained to the fourth year of high school in each of fifty-one cities varies from thirty-eight percent in Newton, Mass. to three percent

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13. See Bibliography, page 2, no. XIII.

in Wheeling, West Virginia. The traditional curriculum in which mathematics played such a big part has to a great extent eliminated those pupils by the conditions it imposed upon them. If our schools wish to be efficient, then the curriculum must be so adjusted as to meet the needs of individual pupils. They must be shown that the mathematics they are studying is of real value to them--that its study will help them in real life situations. The mathematics course in the past has been judged wanting, but it must not continue to be so.

It must be very evident to all readers that the traditional mathematics curriculum, which was undemocratic, based upon unsound educational theories, static, and unsatisfactory in its results, was thereby inefficient and in need of reform. During the past twenty five years various influences throughout the country, have been at work for the betterment of the syllabi offered in the schools.[20] These influences include the following:- The work of the International Commission on the Teaching of Mathematics, the work of the National Committee on Mathematics Requirements, the revised requirements of the College Entrance Examination Board, the rise of the Junior High Schools, the work of the schools of education in the universities, the text-books, and the Spirit of the Times.

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20. See Bibliography, Page 2, NO.XX.

Here, it is not my purpose to go into a study of the work or accomplishments of each one of these various agencies for improving the course in mathmetics. I shall not even attempt to show the gradual progress and development of all these influences together, in reorganizing the mathematics curriculum. My purpose is merely to show briefly the results which have been accomplished in twenty five years by all these factors cooperating, and working towards a single objective--the improvement of mathematics. Though my study includes the whole field of secondary school mathematics, I felt it wiser to consider the present status of mathematics in the Junior High Schools and in the Senior High Schools separately, owing to the different stages in the progress of curriculum reconstruction in the two schools.

The crying need for some time has been a scientifically constructed curriculum policy.[23] A change in course however must always be preceeded by a modification in our conception of the aim of education. Only after such aims as social efficiency have been discussed for a number of years in the educational press and forum, do changes in the curriculum begin to appear. Even then, there is no immediate or wholesale change--the change in the curriculum running on an average of ten years behind the advocating of such a movement.[24]

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23. See Bibliography, Page 2,no. XIII.

24. " " " 3, no. XIV.

The guiding principle for selection of mathematical content for the Junior High grades, as set up by the National Committee in their report,(10) is that the course should be planned as a unit with the purpose of giving each student the most valuable mathematical training he is capable of receiving in those years, with little reference to courses which he may or may not take in succeeding years.

With the seven main objectives for secondary education--health, command of fundamental processes, worthy home-membership, vocation, citizenship, worthy use of leisure time, and ethical character---as reported by the commission on the reorganization of Secondary Education in its pamphlet,"Cardinal Principles of Secondary Education", and the three specific aims of mathematical instruction as defined in the "Reorganization of Mathematics in Secondary Education", in 1923,(10) namely, practical aims, disciplinary and cultural, -- the movement of reorganization of the mathematics program in secondary schools was given a great impetus.

Since the inheritance handed down through the schools is so massive that it can never be entirely assimilated, a selection is always necessary, and the basis for this selection is the statement of the aims. The curriculum builder,then, will either have to choose topics from a

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10. See Bibliography, page 1, no. X.

study of the subject itself, which will best carry out these aims, or he may base the course on objective studies of social needs. At present, about thirty scientific studies , which have more or less bearing on the selection of materials in mathematics for our secondary schools,are available.(25) They include an analysis of pupil activities, studies of the uses of mathematics in general readings, studies of the social and business activities of adults, and investigations of the academic uses of mathematics by High School and College students in subjects other than mathematics. Among the best and most helpful of these surveys are those made by Charters,(11) Chase,(26) Mitchell,(31) Wilson,(27) and Woody,(29) to discover the uses various citizen groups make of mathematics.

On the basis of reports and investigations such as these, the mathematical content of the seventh, eighth, and ninth grades has changed to a considerable extent. There are two groups for whom the Junior High school must provide:-

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25. See Bibliography, page 3, no. XXV.
11. " " " 2,no.XI.
26. " " " 3, no. XXVI.
31. " " " 3, no.XXXI.
27. " " " 3, no.XXVII.
28. " " " 3, no.XXVIII.
29. " " " 3, no.XXVIV.

those who drop out during or after the junior high school period, and those who continue through to the end of the senior high school. The effort has been made to open the door of mathematics to all in order that all may have a general knowledge, such as an average intelligent citizen would need, and that those, who continue school, may be able to decide intelligently whether or not to elect further work in this field.

In "A Survey of Progress" of the last twenty five years by David Eugene Smith,[20.] it is noted in regard to arithmetic , that the aim has changed--the purpose today has come to be recognized as the acquisition of power to calculate within the limits of the needs of the average well-informed citizen. Some of the topics studied by the children are the arithmetic of daily life, including the keeping of a budget, check-book, bank account, and reading meters; the arithmetic of civic life, such as the expenses of the city and national government; the arithmetic of business and industry, such as the cost of production and transportation, buying, selling, labor and wages.

The new purpose in the teaching of algebra is to give everyone a general idea of the meaning of algebra, together with the few definite and useful applications which everyone is likely to meet. The topics most stressed are the formula, graph, the directed number, the linear equation with one

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20. See Bibliography, Page 2, no. XX.

unknown, and numerical trigonometry. In the matter of algebraic problems, there has also been a notable advance. The problems found today in the text-books are the applied rather than the illustrative type--that is, they are concrete, serving as instruments in meeting certain definite social needs of the pupil in the home, the school or community.

Within recent years there has been a definite differentiation between intuitive and demonstrative geometry. Intuitive geometry, which naturally precedes demonstrative, has come to be taught in the seventh and eighth years. For those continuing in school, it has been found that this early training is helpful in the more advanced work, while for the rest, it gives a general concept of space and measurement which should be possessed by every intelligent person. Although demonstrative geometry is sometimes taught in the junior high schools, because of the fact that its purpose is to show the application of logic to the proof of mathematical statements, it is generally felt that the work requires a maturity of mind hardly found before the tenth school year.

These mathematical subjects are introduced at various times in different schools--the attempt being made to correlate the three, rather than keep each as a separate unit

for an entire year. A very good example of a program in which the three branches above mentioned are introduced each year, but with a corresponding increase in difficulty, is the syllabus as outlined by Mr. Barber for the Newton Junior High Schools. As this outline was planned in 1922, it is not followed strictly today, but is the general basis of the work which is done there. It will be noticed that there is no arrangement as to sequence or time, but as they use Mr. Barber's text-book, they followed his arrangement fairly closely. The outline given below is not complete, but is sufficient to show the general trend and the main features emphasized each year.

Syllabus.

Grade VII.

1. Mensuration- Measurement.
   a. Measurement of straight lines, angles, and perimeters of plane rectilinear figures.
   b. Drawing to scale.
   c. Straight line graphs.
2. Mensuration-- Computation.
   a. Informal development of perimeters of parallelograms and triangles.
   b. Computation of perimeter of parallelograms and triangles.
      (1) Data obtained from actual measurement.
      (2) Assigned data.
3. Arithmetic review.
   a. Addition and subtraction with check.
   b. Multiplication and division with preliminary round number estimate.
4. Formulas and Equations.
   a. P=a+b+c.
   b. P=2w+2l.
   c. P=4a
5. Percentage

Grade VIII.

1. Mensuration and Measurement.
   a. Distinction between a counted and measured number.
   b. Construction of lines, triangles, quadrilaterals.
   c. Graphical representation of statistics by lines and areas.
2. Mensuration- Computation.
   a. Informal development of perimeter and area of trapezoid and circle.
   b. Computation of perimeter and area of these figures
   c. Square root by trial method--Pythagorean Theorem.
3. Arithmetic Review.
4. Percentage.
5. Arithmetic of the home and civic life; taxes briefly; insurance.
6. Formulas such as the following to be used as opportunity offers:
   a. s=ab
   b. s=bh
   c. s=½bh. et cetera.
7. Equations with one unknown derived from problems and solved by addition, subtraction, multiplication, and division.

Grade IX.

1. Problems leading to easy equations.
   a. From general sources.
   b. From geometrical sources.
2. Approximate computations.
   a. Significant figures.
   b. Four fundamental operations with measured numbers.
3. Evaluation.
   a. Formulas--triangles, parallelograms, circles.
   b. Formulas from sources----industry, science.
4. Algebraic expressions and processes arising from lands.
5. Problems
6. Special products and factoring leading to quadratic equations.
7. Quadratic and simultaneous equations.
8. Simple numerical trigonometry.

Because of the fact that the Junior High school is still in a state of flux, no single text book or syllabus at present can adequately represent the ideal practice of a typical Junior High school. Whatever is given, must be regarded simply as provisional and tentative.[23]

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23. See Bibliography, Page 2, no. XXIII.

In concluding this brief review of junior high school mathematics, I am including a few statements from a survey made a few months ago of "Current Practice in Junior High School Mathematics" by Edward H. Worthington.[31] Since his investigation included fifty one junior high schools, his conclusions are quite significant, and serve as a summary of the present status of mathematics in the junior high schools.

Summary:

1. Mathematics is required usually five periods per week in grade seven and eight, while the pupil is frequently permitted in grade nine to choose between algebra, general mathematics and business arithmetic.
2. Several of the old type texts are still in use, although most of the Junior High Schools are turning to the newer type of text.
3. Numerical trigonometry is gradually gaining friends, and demonstrative geometry is making some progress. Many teachers and administrators are still ignorant of these terms however.
4. Such topics as logarithms, and slide rule are on supplementary list in most text books, and teachers are not anxious to teach them. Statistics, on the other hand, is making great strides.

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31. See Bibliography, Page 3, no.XXXI.

Now the changes in the courses in the senior high school are naturally based upon the assumption that changes in the junior high school courses require them, or that principles which are affecting a reorganization of the junior high school courses are equally applicable to those of the senior high school.(32) When we consider the tentative condition of mathematics in the seventh, eighth and ninth grades, it is not so surprising that very little has been done in the way of a reorganization in the senior high school. It is quite a well recognized fact that " there are relatively few innovations under way in the later years of the senior high school."(10)

As regards principles for the selection of subject matter, the big difference between the junior and senior high school is that in the latter period, it is considered proper that some attention be paid to the students' vocational or other educational needs.

Outside of a few experimental schools, such as the Horace Mann School for Girls in New York, which has attempted to work out a course in Senior High School mathematics, based upon problems which arise in life, and which require for their solution certain mathematical processes, very little, if anything, has been done to arrange a scientific course, at all comparable to the Junior High. While it is generally recognized today,

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32. See Bibliography, page 4, no.XXXII.

10. " " " 1, no. X.

that the senior high school should allow specialization to prepare for future needs, whether it be college, technical school, business, or a trade, this view is largely in the theoretical or ideal state at present. In the study of geometry, for example, whether the class be a vocational, academic, or technical one the traditional plane geometry book occupies a most prominent place.

There have been some improvements, however, in the senior high school. The number of demonstrated theorems in geometry has been greatly reduced, and there has been a tendency likewise to shift the emphasis from book propositions to originals.(10) An increase in the number of geometry exercises for the pupilshimself to do has been met by a decrease in the difficulty of the work. In place of the very technical and formal work in algebra and geometry which has been eliminated, solid geometry, calculus, and more advanced trigonometry are being introduced in many high schools.

The great difference in the progress of the senior high school as compared with the junior high is evident from a glance at the syllabus of a very modern high school

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10. See Bibliography, Page 1, no. X.

in New York. Ralph Beatley, reporting on the mathematics in the Horace Mann School for boys, outlines the course for grades seven, eight, and nine.(33) The work corresponds fairly closely to the outline of a modern junior high school as quoted above. Intuitive geometry, algebra and arithmetic are correlated, and work with logarithms, the slide rule, graphs, and numerical trigonometry is also introduced. The mathematics in the senior high school was elective and resembles pretty closely the old traditional course. A brief outline of this work as given in the Mathematics Teacher follows:-

Grade X.Algebra and Geometry.

1. The laws of exponents;radicals; quadratic equations; simultaneous equations; progressions; binomial theorem; proportion; variations,literal equations; equations of any degree. Review of algebra including abstract problems.
2. Plane Geometry, Book I and Review.
   Original exercises---part of Book II.

Grade XI. Geometry.

Books II.-V. Intuitional Solid Geometry.
Review of Plane Geometry.Originals.

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33. See Bibliography,page 4, no.XXXIII.

Grade XII. Geometry-Trigonometry-College Algebra

1. First Term-Solid Geometry
2. Second Term-Plane Trigonometry and College Algebra.

It can be readily seen, then, that as far as content is concerned, the change between the senior high school curriculum of twenty-five years ago and that of today has been very slight. Consequently, whatever could be said about the functioning power of mathematics, as it was taught a generation ago to the parents of our present students, can be said in a general way about its functioning power now. Those schools which give specific mathematical training in the senior high school for pupils in the science, mechanics, household arts, industrial arts, and commercial groups are the exception rather than the rule.

PART II.

With a view to determining just how much mathematics, as it was taught in the secondary schools, was functioning in real life, at the advice of Dr. Wilsin, I decided to make an investigation. Because of the facy that the subject matter has not changed to any considerable extent in the Senior High School, it seemed that a study of the functioning value of mathematics as shown by the experiences of those who have studied it, and, as far as length of time is concerned, should have had opportunity to use it, would be valuable in determining what the new mathematics course should contain.

According to the report of the National Committee on the Reorganization of Mathematics, there are three aims in teaching this subject ----- (1) Practical or utilitarian, (2) Disciplinary, (3) Cultural. In my investigation, I have tried to keep these three in mind, and, with the exception of the cultural aim, (for which I substituted "worthy use of leisure time") made them the basis for my investigation and questions.

The High School, at which I did my practice teaching, is a six year course, which prepares girls for college and other institutions of higher learning. Because of the fact that it is a central rather than district high school, and that those who are sent there intend to study further, it

seemed a rather safe proposition to conclude that the parents, --many being in the professions--- had probably received at least a gigh school training. If any could make use of mathematics, formal as it certainly was in their day, I felt that this group of normal, average intelligence, and a fairly good education, would have found its use and application.

And so with the consent of the principal of the school, I prepared a questionnaire addressed to the parents of the girls with whom I came into contact in my teaching. It was on Dr. Wilson's suggestion that I included a question in regard to the recreational value derived from a study of mathematics. I also wish to acknowledge the suggestion of Mr. Earnest Hapgood, the principal, that I specify in question seven some of the benefits which a student of mathematics might be expected to derive from its study.

Following is a copy of the questionnaire:--

To the Parents:-

We spend much time in the schools ,in teaching algebra and geometry. We want to check up to see how much use is made of this knowledge by adults. Will you help us by filling in the blanks below?

	FATHER	MOTHER
1. Name	_____	_____
2. Occupation	_____	_____
3. Have you ever studied algebra or geometry?	_____	_____
4. Have you ever made any specific use of either?	_____	_____
5. If so, note fully.	_____	_____

6. During the past year, have you ever turned to algebra or geometry for an hour or so for pleasure?

_____ _____

7. Beside practical usage and pleasure, do you believe there might be any other benefits to be derived from a study of these subjects? Check below any which you feel you have gained;-

Accuracy	_____	_____
Concentration	_____	_____
Logical Reasoning	_____	_____
Power to Generalize	_____	_____
Development of Constructive Imagination	_____	_____
Growth of Mental Self-Reliance	_____	_____

These questions were given to three tenth grade classes, two ninth grade classes, and to one eighth grade class,-- totalling in all about one hundred and fifty-eight pupils. The children were asked to take them home and have their parents

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fill them out. In spite of my many requests that they be returned as soon as possible, I found that at the end of the month when my practice teaching and observation period was over, I had only eighty papers on file. As this was about fifty percent,--a fairly high rate of return, I am told,-- I have attempted to summarize the data such as it is

On twenty-three of the papers which were returned, one of the columns , euther for the father or mother, was left blank. Upon inquiry from the teacher, I found that,in several cases, one parent was either dead or away from home , and so I have disregarded this number entirely, since I had no evidence from them either way. This left one hundred and thirt-seven parents from whom I received the following data.

Table I. which follows shows the range of occupations represented by the returned questionnaire, the number in each vocation, who had studied algebra or geometry, and the percentage of those in the different vocations, who had studied high school mathematics.

TABLE I.

Occupation	No. of Replies	No.having studied algebra & geometry.	No.having studied algebra alone.	No.having studied geometry alone.	Percentage of those in different vocations having studied algebra or geometry.
At home.	64	37	5	0	65
Building Constructors & Engineers.	7	6	0	0	85
Clergymen.	3	3	0	0	100
Clerical positions.	5	4	0	0	80
Designers & Draftsmen.	3	2	0	1	100
Lawyers	5	5	0	0	100
Merchants & Buyers.	17	9	0	0	53
Physicians & Dentists.	6	6	0	0	100
Real Estate	2	2	0	0	100
Skilled Labor (Mechanics, Painters, & Plumbers)	9	2	0	1	33
Teachers.	2	2	0	0	100
Miscellaneous.	14	5	1	0	36
	137	83	6	2	66 Totals.

TABLE II.

Occupations.	No. having studied algebra or geometry.	No. having made specific use of either.	Number stating the use made.	Percentage of those having made specific use of it.	Percentage of those who state definitely the use made of it.
At home.	42	5	2	12	5
Building Constructors & Engineers.	6	3	3	50	50
Clergymen.	3	2	2	67	67
Designers & Draftsmen.	3	2	2	67	67
Clerical Positions.	4	1	1	25	25
Lawyers.	5	2	0	40	0
Merchants & Buyers.	9	4	3	44	33
Physicians & Dentists.	6	1	1	17	17
Real Estate.	2	0	0	0	0
Skilled Labor (Mechanics, Painters, Plumbers.)	3	2	2	67	67
Teachers.	2	1	1	50	50
Miscellaneous.	6	3	2	50	33
Totals	91	26	19	28	20

The data received in answers to questions four and five is summed up in Table II. I might add here that I believe the percentage in the last column, that is those who were able to state definitely a use made of their mathematics, is probably more authentic than in the fourth column. As can be easily perceived from a study of the table, there was quite a variation, in many cases, between the number who said they had made use of it, and those who could state the use made.

TABLE III.

SPECIFIC USES MENTIONED.

Occupations.	Business	Professional	Avocational	Helping Children
At home.		1 (Former Teacher)		1
Building Constructors & Engineers.	3 (problems of engineering)			
Clergymen.		1 (Teacher)	1 (Architecture & insurance.)	
Clerical Positions.	1 (Public Acc't)			
Designers & Draftsmen.	2 (Perspective drawing)			
Merchants & Buyers.	2			1
Physicians & Dentists.		1 (Dentist)		
Skilled Labor	2 (Work of mechanic & machinist)			
Teacher.		1		
Miscellaneous.	1 (Travelling Salesman)		1 (Picture Producer)	
Totals	11	4	2	2

Table III. gives the specific uses which were mentioned in reply to question five. Though none of them are very definite, I feel that this was because of a lack of understanding on the part of those who answered as to just what was wanted. Though all

are worthy aims, I do not believr we could make the last one a definite objective for teaching mathematics. If this was the only use made of it, we would be forming a vicious circle if we taught pupils mathematics simply in order that they in turn might teach and help their children.

In reply to question six, "During the past year, have you ever turned to algebra or geometry for an hour or so for pleasure?"--- thirteen said yes. One specified that he enjoyed geometry, but not algebra, making a total of fourteen, who felt that their study of these subjects had contributed something toward a worthy use of leisure time. Of these fourteen, six were among those, who had made use of algebra or geometry for some specific purpose, while the other eight who derived pleasure from it had made no use of either.

The third objective whose functioning I have attempted to test out is that of "mental Discipline". Of the various benefits besides practical usage and pleasure, which were listed in the questionnaire, "logical reasoning" received the greatest number of checks. This was followed in point of frequency by "accuracy"(64), "concentration"(58),"growth of mental-reliance" (43), "power to generalize"(34),and "development of a constructive imagination"(34).

It was interesting to note in this regard that many of the papers called attention to the fact that other subjects as well as mathematics would develop the same or similar traits, perhaps even to a greater extent in certain other people.

TABLE IV.

MENTAL DISCIPLINE BENEFITS.

Occupations	Total number having studied algebra or reometry.	Accuracy	Concentration	Logical Reasoning.	Power to Generalize	Devel't of constructive imagination.	Growth of mental self-reliance.
At home.	42	30	28	28	14	13	19
Building Constructors & Engineers.	6	2	1	2	2	2	2
Clergymen.	3	3	2	3	1	2	2
Clerical Positions.	4	3	3	4	2	1	1
Designers & Draftsmen.	3	3	2	3	1	2	2
Lawyers.	5	3	4	4	3	1	2
Merchants & Buyers.	9	6	5	6	4	4	6
Physicians & Dentists.	6	4	2	4	1	1	1
Real Estate.	2	0	1	2	0	1	1
Skilled Labor.	3	3	2	3	2	2	2
Teachers.	2	2	2	1	1	1	1
Miscellaneous.	6	5	6	6	3	4	3
Totals.	91	64	58	66	34	34	43

I do not believe too much reliance can be placed on the authenticity of the data in Table IV. Out of the ninety-one who studied algebra or geometry, nineteen checked every one of the benefits listed, and in a great many of the papers, both parents checked identically the smae ones, showing little individual thought or consideration on the matter.

A number of the parents added comments on mathematics from their own experiences, and many of these have been very helpful and enlightening in my study of the curriculum.

A clergyman writes: "My avocations could greatly profit by them(algebra and geometry) if my training in them had been connected with real life. It is deplorable that no teacher ever gave me any instruction in types of situations needing them. I had one of the best teachers in the country, but he never began with difficulties out of life's experiences to show why higher mathematics was devised and developed."

A very wise criticism is this, and should be kept in mind by the curriculum builder of mathematics in the senior high school.

From an educator and engineer , the following was taken:- I received more benefit and inspiration from the personality of my geometry teacher than from the subject itself. I think with boys these subjects may be made decidedly beneficial, but with most girls, they fail to function and often amount to nothing mor than solving a puzzle. Less 'abstract' teaching and more concrete tie-up with real things in both subjects

would 'net' more development of imagination."

Constructive criticism of this type is always welcome. It is this tie-up with the real things of life which is lacking, and was a big factor in making the old curriculum inefficient.

A business man believes "that both(algebra and geometry) are valuable in training tha mind as foundations for other courses, and are unconsciously used in the understanding of everyday problems." Evidently, this man was fortunate in his teachers and his training, with the result that for him, there was a definite transfer of certain abilities and powers, which could be attributed to his study of mathematics.

Summary:-

To sum up the data gathered from this investigation, it it is found that out of the 137 replying, 91 or approximately 66% of the parents , representing more than 13 different vocational groups, had studied algebra or geometry in high school. Of this number, 26 or approximately 28% stated that they had made a specific use of it, but only 19 of these were able to stste what this use was. Since the others were unable to mention even a singlr instance, it is probable that the latter figures are more correct. Inregard to the specific uses mentioned, 11 were for business purposes, 4 used it in their professions (3 being teachers), 2 for avocational ends, and 2 for helping their children. Disregarding these latter 2, since such a purpose could hardly be considered from a utilitarian

stand point at least, 17 of the parents or 18% of the entire number,who had studied these subjects, had ever made a definite, specific use of high school mathematics.

The question in regard to the functioning of mathematics from the point of " worthy use of leisure time" revealed the fact that 14 of the 91 or about 15% turned to algebra or geometry for pleasure during the past year. As I have already summed up the data pertaining to the functioning of mathematics from the "mental discipline aspect" on page thirty-seven, I will not repeat it here.

Part III. Conclusions.

Since the Junior High Schools have been established for such a relatively short time, it would be impossible as yet to judge from the experience of those, who have had the benefit of the new mathematics course, whether or not it is actually functioning in their lives. And yet, because of the contributions to the syllabus made by men who have scientifically decided upon dominant ideals, investigated the uses made of mathematics by different vocational groups, and analyzed the the extra-vocational life to discover the extent of mathematical knowledge, which should be common to every intelligent person,-the mathematics taught in the first three years of the

secondary schools must function in real life, since it was from real life that the content of the course was drawn.

In the field of Senior High School mathematics, we are forced from the data obtained through the questionnaires to come to the conclusion that it is not functioning, as it should, for life. Though one of the aims in teaching mathematics was for utilitarian purposes, the data does not show that this end has been accomplished. If only eighteen percent of the entire group (a rather selective one at that) could recall any use that had ever been made by them of algebra or geometry, it is fairly certain that mathematics is not functioning on the whole for practical purposes in the lives of those who have studied it.

Just as all subjects in a currucula are of some educational value, so too in every class, there are some, who, because of special abilities, derive much more benefit from the course than others. But, because these very few find a use for mathematics, it does not follow, as a general thing, that all can make use of it.

In a similar way, we must conclude that mathematics is not functioning to any extent in the field of "worthy use of leisure time", since only about fifteen percent of those who studied it, ever turned to this subject for pleasure.

Judging from the group investigated, I should say that the largest field in which mathematics is functioning is in the development of certain habits and qualities of mind,such

as accuracy and logical reasoning. However, since these are the reasons which have been attributed by the traditional mathematics teachers for the study of this subject, it may be that the members of this group, who replied, are relying largely for their belief on faith---that what they were told would result from their study has actually resulted. Several of the parents admitted that they could not tell whether or not it was mathematics (rather than some other subjects) which had brought about these desired attitudes and habits.

Since the investigation has shown that secondary school mathematics,as it was taught a generation ago to the parents of our present students, is not functioning to any extent in their lives, either for practical purposes or purposes of leisure, and a study of the curriculum has revealed that the mathematics course in the senior high school today has changed but little from that of former times, pupils should not be forced to take such a course(unless they have a special desire to do so) until, after scientific studies, it can be shown that such a course is needed for general purposes by the average person, and that it can and will function in their lives.

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